NeoBiota 32: 21–29 (2017)
doi: 10.3897/neobiota.32.9429
http://neobiota.pensoft.net

SHORT COMMUNICATION

A peer-reviewed open-access journal
NeoBiota
Advancing research on alien species and biological invasions

The European Alien Species Information Network on the Convention on Biological Diversity pathways categorization

Konstantinos Tsiamis[1], Ana Cristina Cardoso[1], Eugenio Gervasini[1]

1 *European Commission, Joint Research Centre – Directorate for Sustainable Resources, Water & Marine Resources Unit, Ispra, Italy*

Corresponding author: *Konstantinos Tsiamis* (konstantinos.tsiamis@jrc.ec.europa.eu)

Academic editor: *F. Essl* | Received 3 June 2016 | Accepted 31 July 2016 | Published 4 January 2017

Citation: Tsiamis K, Cardoso AC, Gervasini E (2017) The European Alien Species Information Network on the Convention on Biological Diversity pathways categorization. NeoBiota 32: 21–29. https://doi.org/10.3897/neobiota.32.9429

Abstract

The adoption of a consistent alien species pathways categorization, hierarchy and terminology is crucial for increasing the interoperability of different online databases. In the present paper the European Alien Species Information Network (EASIN) classification system of pathways is compared and discussed with the classification scheme recently published by the Convention on Biological Diversity (CBD). Although the main pathway categories of the two classifications overall match, there are substantial differences in their subcategorization, with EASIN including 20 pathway subcategories while CBD considers 44 subcategories. In most cases, each EASIN subcategory pathway can correspond to two or more CBD subcategories. About 5,500 species listed in EASIN do not match directly with the CBD pathway subcategories, most of which are terrestrial invertebrates. Aiming at achieving synchronization between the two classification systems and at facilitating the access to information to researchers and policy makers, EASIN is trying to align with the CBD pathway classification scheme. This alignment process requires the involvement of a large number of experts, especially from the terrestrial realm, and the adoption of commonly accepted definitions of the CBD pathways.

Keywords

alien, invasive, Europe, interoperability, pathway, EASIN, CBD

Copyright *Konstantinos Tsiamis et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Invasive Alien Species (IAS) constitute one of the most important threats to biodiversity, causing severe ecological and socio-economic impacts (Ricciardi et al. 2013, Jeschke et al. 2014). A conservative estimate of the annual damage caused in the European Union (EU) by IAS is €12 billion (Kettunen et al. 2009). In addition, there is an increasing trend of new alien introductions (Essl et al. 2015, Roques et al. 2016). Aiming at protecting European biodiversity, the European Parliament and the Council adopted the EU Regulation no. 1143/2014 (EU 2014; hereafter referred to as the IAS Regulation) on the prevention and management of the introduction and spread of IAS, which entered into force on the 1st of January 2015, and a list of 37 invasive alien species of Union concern, by means of Implementing Regulation 1141/2016.

The European Alien Species Information Network (EASIN, http://easin.jrc.ec.europa.eu/) has been developed by the European Commission's Joint Research Centre (JRC) (Katsanevakis et al. 2012), and formally recognized as the information system supporting European Member States in the implementation of the IAS Regulation (EU 2014, Art. 25). EASIN aims at allowing easier access to data of alien species occurring in Europe, and to provide a one-stop shop to access all the information necessary to underpin alien species related policy and management decisions (Katsanevakis et al. 2013).

Information on alien species introduction pathways is fundamental for the reliability and effectiveness of alien species risk assessments, management, monitoring, and surveillance (EU 2011, Ojaveer et al. 2014, McGeosh et al. 2016). Pathways categorization is an essential aspect, and can benefit from applying consistent pathways classification, hierarchy, and terminology (Essl et al. 2015). To aid these efforts, a standardized pathways terminology and hierarchical classification has been proposed by Hulme et al. (2008) and largely adopted by EASIN in 2012 (Katsanevakis et al. 2012). Since then, EASIN datasets have been used for pan-European or regional assessments of pathways of alien species invasions, towards the fulfilment of the related targets of the Convention on Biological Diversity (CBD) and of European policies (Katsanevakis et al. 2015).

The increasing threat of IAS has lead CBD to a comprehensive review of the alien species pathways, adopting a note of the executive Secretary on the categorisation of identified pathways of introduction of IAS (CBD 2014), addressing the needs of Aichi Biodiversity Target 9 concerning the identification, prioritization and management of IAS by 2020, which is reflected in Target 5 of the EU Biodiversity Strategy (EU 2011). The CBD pathway analysis was based on Hulme et al. (2008) study, and integrates a set of international standards and guidelines, aiming at harmonizing the existing large number of pathways described. CBD (2014) scope is to develop a categorization of pathways using standard terminology applicable at a global scale, facilitating the interoperability of different online databases.

In the present paper a comparative analysis between the EASIN and the CBD pathway classification schemes is presented (Table 1), highlighting the need for harmonization to allow data interoperability. Both systems exhibit very good match (83%) regarding their main-category pathways ("release in nature", "escape from confinement", "transport contaminant", "transport-stowaway", "corridor"), since they are

Table 1. Comparison of sub-category pathways between CBD and EASIN classification systems; green colour corresponds to perfect match between the two systems; blue colour includes cases where an EASIN pathway corresponds to two (or more) CBD pathways; orange colour indicates a case where a CBD pathway corresponds to two EASIN pathways; red colour refers to cases where an EASIN pathway does not match with any CBD pathway or vice versa. The number of related species for each pathway in EASIN is also provided.

Category pathways	CBD sub-category pathways	EASIN sub-category pathways	EASIN No. of Species
Release in nature	Biological control	Biocontrol	181
	Erosion control/ dune stabilization (windbreaks, hedges, …)	Landscaping-Erosion control	64
	Landscape/flora/fauna "improvement" in the wild		
	Fishery in the wild (including game fishing)	Game animals	93
	Hunting		
	Introduction for conservation purposes or wildlife management		
	Release in nature for use (other than above, e.g., fur, transport, medical use)		
	Other intentional release	Other + Pets, Terrarium-Aquarium species	1102
Escape from confinement	Agriculture (including Biofuel feedstocks)	Cultivation and Livestock	780
	Farmed animals (including animals left under limited control)		
	Forestry (including afforestation or reforestation)		
	Fur farms		
	Horticulture		
	Aquaculture / mariculture	Aquaculture	171
	Botanical garden/zoo/aquaria (excluding domestic aquaria)	Zoos, botanical gardens	262
	Pet/aquarium/terrarium species (including live food for such species)	Pets, Terrarium-Aquarium species	246
	Ornamental purpose other than horticulture	Ornamental planting	1935
	Research and ex-situ breeding (in facilities)		
	Live food and live bait	Use of live food-bait	28
	Other escape from confinement		
Transport – contaminant	Contaminant nursery material	Trade of contaminated commodities	3382
	Contaminated bait		
	Food contaminant (including of live food)		
	Contaminant on animals (except parasites, species transported by host/vector)		
	Parasites on animals (including species transported by host and vector)		
	Contaminant on plants (except parasites, species transported by host/vector)		
	Parasites on plants (including species transported by host and vector)		
	Seed contaminant		
	Timber trade		
	Transportation of habitat material (soil, vegetation, …)		
		Aquaculture	228
		Packaging materials	56

Category pathways	CBD sub-category pathways	EASIN sub-category pathways	EASIN No. of Species
Transport - stowaway	Angling/fishing equipment		
	Container/bulk		
	Hitchhikers in or on airplane	Aviation	27
	Hitchhikers on ship/boat (excluding ballast water and hull fouling)	Shipping	921
	Ship/boat ballast water		
	Ship/boat hull fouling		
	Machinery/equipment		
	People and their luggage/equipment (in particular tourism)		
	Organic packing material, in particular wood packaging		
	Vehicles (car, train, …)	Land transport	297
	Other means of transport		
Corridor	Interconnected waterways/basins/seas	Lessepsian migrants	499
		Inland Canals	66
	Tunnels and land bridges		
		Railroads and Highways	38
Unaided	Natural dispersal across borders of invasive alien species that have been introduced through pathways the rest main pathways categories.	OTHER	981

both based on Hulme et al. (2008) concept. The only mismatch observed concerns the "unaided" category, adopted by CBD. EASIN uses instead "other" as a category which includes the "unaided" pathway. On the other hand, substantial differences are observed in the subcategorization of pathways: EASIN includes 20 pathway subcategories, while the CBD includes 44 subcategories (Table 1), and thus offers more detailed information on species introduction channels. A perfect match is observed for 10 pathway subcategories between the two systems. More frequently, each EASIN subcategory corresponds to two or more CBD subcategories, or the opposite in one case, including 24 non-matching pathway subcategories considering both sides. A typical example is the EASIN "trade of contaminated commodities" pathway, assigned to about 3,400 species in EASIN, which could correspond to one or more among the ten related pathways of the CBD scheme (Table 1). Finally, there is no match at all concerning 14 subcategories included in both systems (Table 1).

A thorough comparison between the EASIN and CBD systems reveals that the sub-category pathways of about 5,500 alien species registered in EASIN (51% of the EASIN species with assigned pathway) do not match directly with the available CBD pathway subcategories. Similar comparisons were made by Essl et al. (2015) between the CBD scheme and GISD (Global Invasive Species Database), DAISIE (Delivering Alien Invasive Species Inventories for Europe) and GBNNSIP (Great Britain's Non-Native Species Information Portal) data, revealing higher levels of direct matching (from 79% to 99%). However, the number of species with assigned pathways in these databases is by far lower when compared with EASIN.

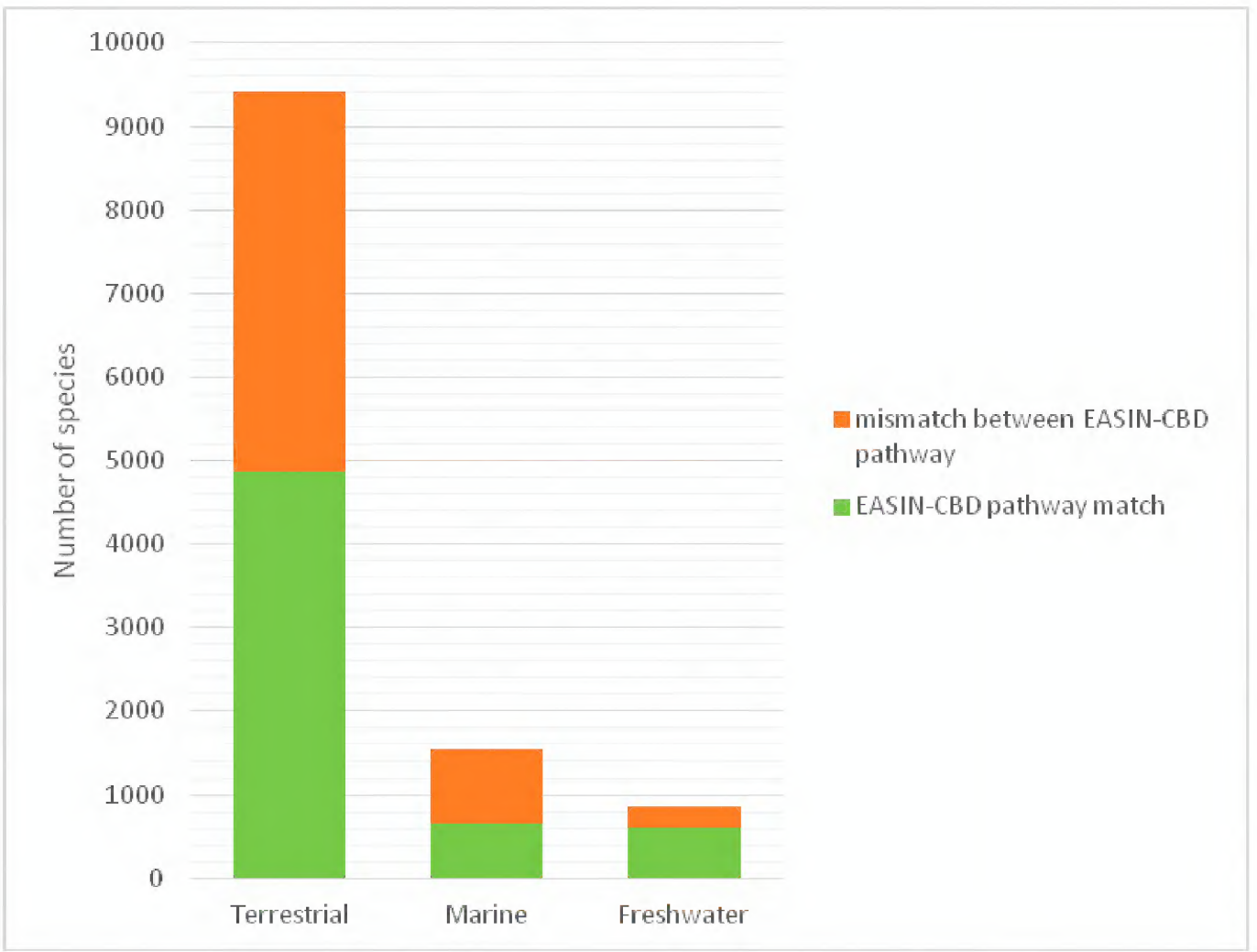

Figure 1. Pathway matching between EASIN and CBD sub-category classification systems for alien species included in EASIN per habitat.

A more detailed analysis of the EASIN data reveals that 52% of the terrestrial alien species included in EASIN match with the CBD classification. In comparison, the matching between the two systems is higher for the freshwater species of EASIN (70%), but lower for the marine species (43%). Still, the corresponding number of the EASIN alien species per habitat is much higher for the terrestrial group compared to the marine and freshwater (Figure 1). When it comes to alien species of EASIN per main taxonomic group, a low match is observed for the invertebrates (28%, Figure 2); most of the mismatched species of EASIN are assigned to the pathway "trade of contaminated commodities" and "shipping" (Figure 3). On the other hand, there is a relatively good match for plants (66%), although given the size of the group, a considerable number of them do not match with the CBD pathways (Figure 2), most of them assigned to "trade of contaminated commodities" and "cultivation and livestock" (Figure 3). A good match is observed for vertebrates (80%), with a low number of mismatched species (Figure 2), most of which are related with 'game animals" and 'shipping" (Figure 3).When it comes to fungi and chromista, there is a very low match for both of them (1% and 22%, respectively), although their species number is by far lower compared to the other main taxonomic groups (Figure 2). Almost all mismatching fungi are assigned to "trade of contaminated commodities", while most mismatching chromista to "shipping" (Figure 3).

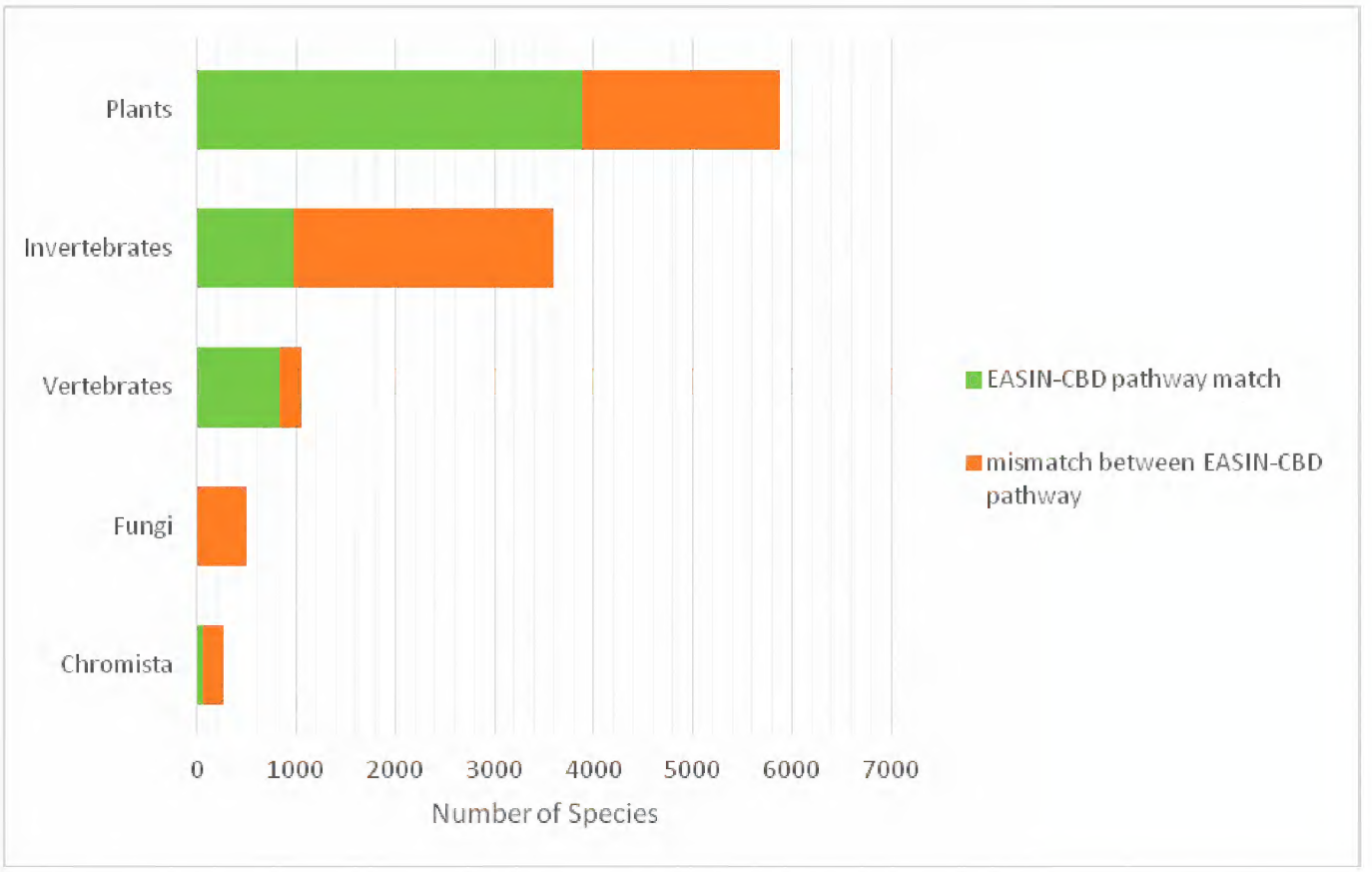

Figure 2. Pathway matching between EASIN and CBD sub-category classification systems for alien species included in EASIN per main taxonomic groups.

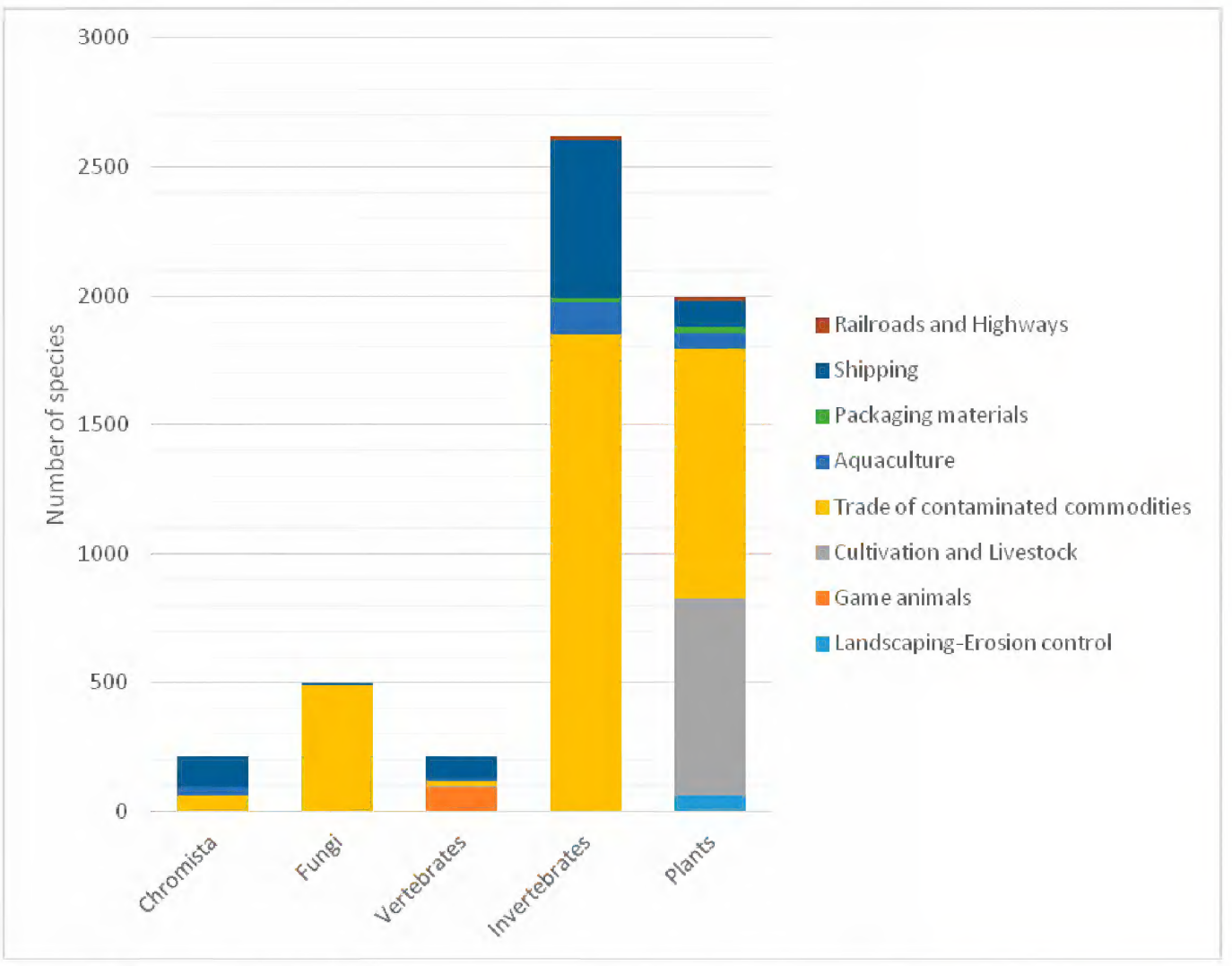

Figure 3. Number of EASIN alien species per main taxonomic group with assigned pathway not matching the CBD classification. The related number of alien species corresponding to each EASIN pathway is also depicted.

It should be noted that the accurate determination of an alien species pathway is not always an easy task and it may be characterised by high levels of uncertainty (Katsanevakis et al. 2013). Therefore, higher level of detail in subcategorization will inevitably lead to further difficulties in pathways accurate determination. For example, it is known that most of the marine aliens in European seas have been introduced through shipping (Nunes et al. 2014), but the accurate assignment of their pathway in terms of CBD subcategories related to shipping ("hitchhikers on ship-boat excluding ballast water and hull fouling" / "ship-boat ballast water" / "ship-boat hull fouling") could offer a real challenge even to experts. On the other hand, higher level of pathways distinction could allow a better definition of legislative instruments or tailored measures preventing the entry of new aliens.

In addition, there are some points in the CBD scheme that need further clarification. For example, the distinction between the CBD sub-category pathways "horticulture" and "ornamental purpose other than horticulture" is not clear and could result in different interpretations among stakeholders. This is especially important for alien land plants, where about 2,000 species in EASIN are assigned to the "ornamental planting" pathway (Table 1).

Still, the need for interoperability among pathway classification systems is today crucial, considering also the recent IAS Regulation implementation needs. Pathway terminology has historically varied among alien species databases (Hulme et al. 2008), restricting comparisons across data repositories (CBD 2014). In order to tackle this, JRC is revising the EASIN pathway classification system and harmonise it with the CBD scheme, aiming at enhancing interoperability and facilitate exchange of information amongst databases on alien species, but also to support the analysis of pathways and their relative importance for prioritising management and to facilitate the development of response options to tackle IAS.

The alignment of the EASIN species to the CBD pathway sub-categories is challenging and resources demanding due to the high number of EASIN species that need to be revised. In some cases this can be relatively simple; i.e. species assigned to "game animals" correspond either to "fishery in the wild" or to "hunting" in terms of the CBD classification. However, for species related with other pathway subcategories (e.g. 'trade of contaminated commodities") their alignment to the CBD system is more demanding and requires deep search in the scientific literature and any other relevant sources of information. Moreover, pathway assignment for less documented species is subject to uncertainty (Essl et al. 2015), setting the need for experts' judgement. Therefore, a large number of experts will be involved in the revision process of the EASIN pathways, covering a broad range of taxonomic groups and habitats. Emphasis should be given to the terrestrial species due to their large number, with the involvement of additional experts, especially when it comes to invertebrates (mostly insects), higher plants and fungi. In addition, uncertainty values attached to each pathway (Katsanevakis et al. 2013) will be included in the alignment process. Finally, it should be noted that the harmonization process of pathways requires a consensus from the scientific community on commonly accepted definitions and related interpretations of the CBD pathways, ensuring homogeneous alignment outcomes.

Acknowledgements

The Authors wish to thank the European Commission Direction General Environment (DG ENV) for their support.

References

CBD (2014) Pathways of introduction of invasive species, their prioritization and management. UNEP/CBD/SBSTTA/18/9/Add.1, Montreal, Canada, 6/2014: 1–18.

Essl F, Bacher S, Blackburn T, Booy O, Brundu G, Brunel S, Cardoso AC, Eschen R, Gallardo B, Galil B, García-Berthou E, Genovesi P, Groom Q, Harrower C, Hulme PE, Katsanevakis S, Kenis M, Kühn I, Kumschick S, Martinou AF, Nentwig W, O'Flynn C, Pagad S, Pergl J, Pyšek P, Rabitsch W, Richardson DM, Roques A, Roy HE, Scalera R, Schindler S, Seebens H, Vanderhoeven S, Vilà M, Wilson JRU, Zenetos A, Jeschke JM (2015) Crossing frontiers in tackling pathways of biological invasions. BioScience 65(8): 769–782.

EU (2011) Our Life Insurance, Our Natural Capital: an EU Biodiversity Strategy to 2020. European Commission. COM/2011/244, Brussels, Belgium, 5/ 2011: 1–16.

EU (2014) Regulation (EU) No 1143/2014 of the European Parliament and of the Council on the prevention and management of the introduction and spread of invasive alien species. Official Journal of the European Union L315: 35–55.

Hulme PE, Bacher S, Kenis M, Klotz S, Kuhn I, Minchin D, Nentwig W, Olenin S, Panov V, Pergl J, Pysek P, Roques A, Sol D, Solarz W, Vila M (2008) Grasping at the routes of biological invasions: a framework for integrating pathways into policy. Journal of Applied Ecology 45: 403–414. doi: 10.1111/j.1365-2664.2007.01442.x

Jeschke JM, Bacher S, Blackburn TM, Dick JTA, Ess F, Evans T, Gaertner M, Hulme PE, Kühn I, Mrugała A, Perg J, Pyšek P, Rabitsch W, Ricciardi A, Richardson DM, Sendek A, Vilà M, Winter M, Kumschick S (2014) Defining the impact of non-native species. Conservation Biology 28: 1188–1194.

Katsanevakis S, Bogucarskis K, Gatto F, Vandekerkhove J, Deriu I, Cardoso AC (2012) Building the European Alien Species Information Network (EASIN): a novel approach for the exploration of distributed alien species data. BioInvasions Records 1: 235–245. doi: 10.3391/bir.2012.1.4.01

Katsanevakis S, Zenetos A, Belchior C, Cardoso AC (2013) Invading European Seas: assessing pathways of introduction of marine aliens. Ocean and Coastal Management 76: 64–74. doi: 10.1016/j.ocecoaman.2013.02.024

Katsanevakis S, Deriu I, D'Amico F, Nunes AL, Sanchez SP, Crocetta F, Arianoutsou M, Bazos I, Christopoulou A, Curto G, Delipetrou P, Kokkoris Y, Panov V, Rabitsch W, Roques A, Scalera R, Shirley SM, Tricarino E, Vannini A, Zenetos A, Zervou S, Zikos A, Cardoso AC (2015) European Alien Species Information Network (EASIN): supporting European policies and scientific research. Management of Biological Invasions 6(2): 147–157. doi: 10.3391/mbi.2015.6.2.05

Kettunen M, Genovesi P, Gollasch S, Pagad S, Starfinger U (2009) Technical support to EU strategy on invasive alien species (IAS) – Assessment of the impacts of IAS in Europe and the EU. Final report for the European Commission. Institute for European Environmental Policy (IEEP), Brussels, 1–44.

McGeoch MA, Genovesi P, Bellingham PJ, Costello MJ, McGrannachan C, Sheppard A (2016) Prioritizing species, pathways, and sites to achieve conservation targets for biological invasion. Biological Invasions 18: 299–314. doi: 10.1007/s10530-015-1013-1

Nunes AL, Katsanevakis S, Zenetos A, Cardoso AC (2014) Gateways to alien invasions in the European Seas. Aquatic Invasions 9(2): 133–144. doi: 10.3391/ai.2014.9.2.02

Ojaveer H, Galil BS, Minchin D, Olenin S, Amorim A, Canning-Clode J, Chainho P, Copp GH, Gollasch S, Jelmert A, Lehtiniemi M, McKenzie C, Mikus J, Miossec L, Occhipinti-Ambrogi A, Pećarević M, Pederson J, Quilez-Badia G, Wijsman JWM, Zenetos A (2014) Ten recommendations for advancing the assessment and management of non-indigenous species in marine ecosystems. Marine Policy 44: 160–165. doi: 10.1016/j.marpol.2013.08.019

Ricciardi A, Hoopes MF, Marchetti MP, Lockwood JL (2013) Progress towards understanding the ecological impacts of nonnative species. Ecological Monographs 83: 263–282. doi: 10.1890/13-0183.1

Roques A, Auger-Rozenberg MA, Blackburn TM, Garnas JR, Pyšek P, Rabitsch W, Richardson DM, Wingfield MJ, Liebhold AM, Duncan RP (2016) Temporal and interspecific variation in rates of spread for insect species invading Europe during the last 200 years. Biological Invasions 18(4): 907–920. doi: 10.1007/s10530-016-1080-y